Scientific contribution/Original research

Overview of Wound Healing Differences between Dogs and Cats

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Abstract:
Wound healing is a crucial process in restoring skin integrity and is very important in all animal species. In veterinary medicine, clinicians often treat dogs and cats according to the same protocols. Yet, many studies have shown that there are differences in skin perfusion, macroscopic appearance of wounds, and even microscopic cell structure of wounds between these two species. It was found that prolonged wound healing and "pseudo-healing" are much more common in cats than in dogs. Understanding the differences in wound healing between these two species may provide clinicians with better outcomes in wound healing treatment. The use of medical honey, intradermal and skin sutures, and longer suture retention may all contribute to better wound healing in cats.

Keywords: Wound healing; Interspecies differences; Granulation tissue; Medical honey; Second intention healing; First intention healing

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1. Introduction

The skin is the largest organ of the body and due to its exposure to the outside, very vulnerable organ. Its integrity is of great importance, especially in protecting the deeper tissues from microorganisms and other external factors (Bohling and Henderson, 2006). Wound healing is a crucial process for restoring skin integrity. It is a dynamic process that begins with an inflammatory phase, followed by a phase of proliferation and then differentiation. Wounds heal according to the same principle in all vertebrates, but there are clinically important differences between species (Bohling and Henderson, 2006; Cornell, 2012).

Macroscopically it is often noted that large open wounds in cats heal slower than similar wounds in dogs and that less granulation tissue forms in cats. As a result of the comparatively slower healing processes, "pseudo-healing" occurs more frequently in cats than in dogs. In "pseudo-healing" the wound appears to be healed but dehiscence occurs after removal of the sutures (**Figure 1)**. One of the reasons for this occurrence could be inappropriate collagen deposition beneath the epidermal surface resulting in lower tensile strength. For this reason, generalization of wound healing characteristics in cats and dogs may be detrimental to individual animals and expose them to stress due to delayed wound healing (Bohling et al., 2004; Pavletic, 2018).

Therefore, the aim of this paper is to highlight differences in cutaneous wound healing between dogs and cats.

Figure 1: "Pseudo- healing" in a cat.

2. Anatomical differences of the skin

The anatomy of the skin of cats is similar to that of dogs. Epidermis, dermis and subcutis are slightly thinner in cats than in dogs. Apart from the fact that skin in cats is looser, more pliable, and more mobile over most of the body surface than the skin of dogs, there are important differences in cutaneous perfusion (Bohling and Henderson, 2006).

Taylor and Minabe (1992) extensively studied angiosomes of mammals and other vertebrates. They concluded that dogs have a greater number of well-distributed cutaneous perforating vessels. Cats, on the other hand, have a smaller number of cutaneous perforators that are more widely distributed in two major lines along the trunk (Taylor and Minabe, 1992; Bohling and Henderson, 2004). They also have a relatively low density of tertiary and higher-order vessels, particularly on the trunk. This conclusion was also confirmed by Bohling et al. (2006) who used laser-Doppler perfusion imaging (LDPI) to assess cutaneous perfusion during wound healing. They found significantly higher baseline perfusion in dogs than in cats (Hartman et al., 1992; Bohling and Henderson, 2004). The lower density of vascular anastomoses, particularly in the trunk region, is reflected in the prolonged healing in cats (Hartman et al., 1992; Bohling and Henderson, 2006).

3. The role of subcutis

The subcutis plays an important role in wound healing. It is the supporting layer of the skin, serves as a flexible connection between the mobile skin and the underlying firm fascia, and supplies vessels and nerves to the overlying dermis (Scott et al., 2001). Studies have shown that removal of subcutis

has a negative effect on wound healing in dogs and cats, but when it comes to second intention healing, the negative effect is much greater in cats than in dogs (Bohling et al., 2006).
Subcutaneous tissue is also an important source of cellular precursors for granulation tissue; however, removal of subcutaneous tissue does not affect the first appearance of granulation tissue, but it slows granulation and wound contraction in both cats and dogs, with cats being more affected. Subcutis removal also impairs epithelialization in both cats and dogs (Bohling et al., 2006; Bohling, 2014).

4. Wound healing

Wound healing can be divided into healing per primam, or first intention healing and healing per secundam or second intention healing (Cornell, 2012).

Surgical wounds that are clean and fresh heal per primam, with suture bringing the edges of the wound closer together (Bohling, 2014). They heal quickly and do not leave large scars. Studies have shown that cats have 50% less tensile strength 7 days after wound closure per primam than dogs with the same wounds. This is thought to be due to significantly lower collagen production in wounds in cats compared to dogs (Bohling and Henderson, 2004). To reduce the risk of dehiscence due to "pseudo-healing", sutures should be left in place for a longer period, at least for 3 weeks. Pavletic (2018) also suggests using intradermal sutures followed by skin sutures to further support incision healing and later reduce incision tension after suture removal.

Healing per secundam means that a wound heals on its own without being sutured. The veterinarian's role in this case is to provide moisture, cleanliness, and protection of the wound. This can be accomplished through appropriate dressings, wound irrigation, and necrotomy (Cornell, 2012). There are many differences in wound healing per secundam between cats and dogs.

In the inflammatory phase, it can be macroscopically observed that canine wounds produce more fluid, are more swollen and erythematous than identical wounds in cats (**Figure 2**) (Bohling and Henderson, 2006; Bohling, 2014). This may be directly related to greater blood perfusion due to the higher capillary density of canine skin (Bohling and Henderson, 2004).

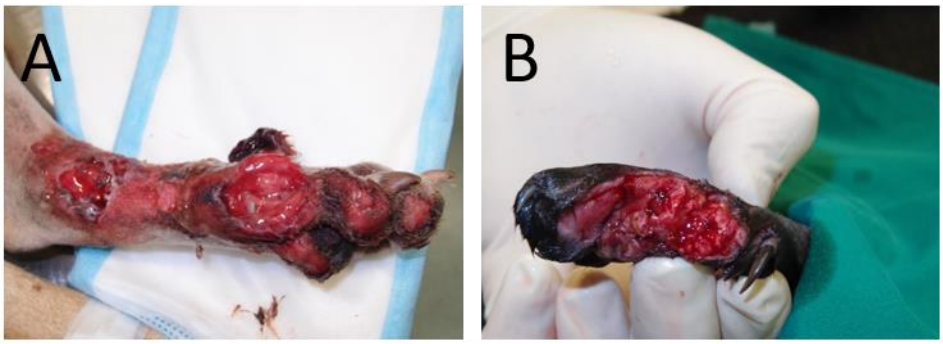

Figure 2: Wound in a dog (A) produces a lot of fluid, is swollen and erythematous compared to wound in a cat (B).

Histologically, there are no interspecies differences in cell infiltration at the beginning of the inflammatory phase, but over time it has been observed that the inflammatory phase is greatly prolonged in cats compared to healing in dogs (Bohling and Henderson, 2004; Bohling, 2014). Deviations in neutrophil granulocytes (indicators of acute inflammation) and mast cells were particularly noticeable, as their numbers were much higher in cats in single measurements from day 7 to day 21, and these cells remained in the wound longer and in higher numbers than in dogs. It was concluded that the inflammatory healing phase is more chronic in cats than in dogs, which may be the reason why the proliferation and differentiation phases occur later in cats (Bohling, 2014).

The appearance of granulation tissue is a definite indication that the wound is entering a proliferation phase (Bohling, 2014). Granulation tissue protects the wound from infection and desiccation (Cornell, 2012).

Bohling et al. (2004) found that the difference in the occurrence of granulation in cats and dogs is only 1-2 days, but in cats the wound granulates more slowly. In their study, they showed that cats take twice as long to fill a skin defect in similar wounds as dogs (Bohling and Henderson, 2004). Cats took an average of 19 days, while dogs completed granulation within 7.5 days (Bohling and Henderson, 2004; Bohling, 2014). However, in our previous study with wounds in cats treated with medical honey the granulation was completed in 9.7 days (Lukanc et al., 2018). Macroscopic differences in granulation tissue are also evident. In cats, the granulation tissue has a lighter pink appearance, whereas in dogs it is dark red (**Figure 3**). The reason for this could again be greater blood circulation in dogs (Bohling, 2014).

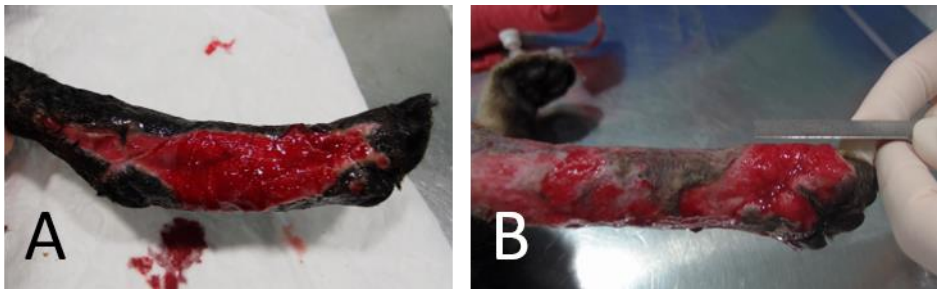

Figure 3: Granulation tissue in a dog (A) has darker colour than in a cat (B), where it is lighter.

In Bohling's study, it was observed that granulation in cats occurs only from the edges of the wound toward the centre, while in our previous study of wound healing with medical honey in cats (Lukanc et al., 2018, Lukanc et al., 2020), we observed the appearance of small granulation islands over the entire exposed surface of the wound, growing in all directions until the skin defect was filled, which is similar to that observed in dogs (**Figure 4**). The study also showed that medical honey promoted earlier appearance and faster coverage of the wound bed with granulation tissue, compared with other studies in which medical honey was not used (Bohling et al., 2004; Bohling et al., 2006). Therefore, we recommend the use of medical honey in wound healing in cats because it not only promotes faster healing but also provides protection for the wound and thereby decreases bacterial growth.

Figure 4: Small islands of granulation tissue along the entire exposed surface of the wound in a cat (Photo: Erjavec V.).

Since the epithelialization and contraction phases of the wound do not occur until the wound is filled with granulation tissue, these two phases are also significantly prolonged in cats (Bohling and Henderson, 2004). Bohling et al. (2004) found that open wounds contracted much slower in cats by day 7, but by day 14, the percentage of contraction was still greater in dogs, although, the differences between groups were not as significant. In cats it may take a longer for differentiated fibroblasts or myofibroblasts to appear in the wound, but once contraction begins, it is faster in cats than in dogs (Bohling and Henderson, 2004). This hypothesis is supported by studies that have shown that fibroblasts that appear early in wound contraction do not contract as much as those that appear later (Rudolph et al., 1992).

5. Other differences

Due to their unique skin characteristics, cats tolerate radiotherapy better in terms of overcoming the side effects that occur on the skin. It is also important to point out that skin grafts heal faster in cats and there are fewer rejections and complications associated with such procedures. Skin grafts are thinner than in dogs and are therefore relatively better nourished – in the initial stages by the process of diffusion from deeper tissues, and in later stages also by earlier revascularization. Because dogs

experience increased transudation and swelling of the wound during the inflammatory phase, this is not ideal for skin grafts and quickly leads to graft rejection (Bohling, 2014).

6. Conclusion

Cats and dogs should be treated separately when healing skin wounds. In cats, care should be taken not to remove sutures too quickly as they are slower to gain the tensile strength of the wound. It is also important to realize that the time during which the wound is protected only by the work of a veterinarian (with dressing, irrigation, etc.) is much longer in cats than in dogs, because the natural protection by the granulation tissue starts later.

Although dogs and cats are often treated by the same protocols, recent studies indicate a need to better understand the differences in physiology between species. It is up to veterinarians to use these findings to improve the quality of clinical practice, help the patients, and most importantly, do no harm.

Conflicts of Interest: The authors declare no conflict of interest.

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